

REMARKS

Claims 12-13, 18-19, 21-22, 24-25, 27, 29, 31, 33 and 35 are currently pending in the present application.

In the Office Action, the Examiner rejects claims 12-13 and 31 under 35 U.S.C. §103(a), as being unpatentable over European Patent Publication No. EP 0785294A of De Nora ("De Nora"), in combination with U.S. Patent No. 4,872,958 of Suzuki, *et al.* ("Suzuki"). In the Office Action, the Examiner also rejects claims 12-13 and 31 under 35 U.S.C. §103(a), as being unpatentable over U.S. Patent No. 6,042,702 of Kolouch, *et al.* ("Kolouch"), in combination with Suzuki. In the Office Action, the Examiner rejects claims 12-13, 31, 33 and 35 under 35 U.S.C. §103(a), as being unpatentable over U.S. Patent No. 5,766,429 of Shimamune, *et al.* ("Shimamune"), in combination with Suzuki. In the Office Action, the Examiner rejects claims 18-19, 21-22, 24-25, 27 and 29 under 35 U.S.C. §103(a), as being unpatentable over Shimamune, in combination with U.S. Patent No. 4,242,184 of Ford and Suzuki. Finally, in the Office Action, the Examiner rejects claims 12-13, 18-19, 21-22, 24-25, 27, 29, 31, 33 and 35 under 35 U.S.C. §103(a), as being unpatentable over U.S. Patent No. 4,526,663 of Yoshida, *et al.* ("Yoshida"), in combination with Suzuki. In each instance, the Examiner acknowledges that the primary references fail to explicitly teach a gas diffusion electrode and an adjacent ion exchange membrane having a contact area of at least 50% of their geometric area, but argues that this claimed attribute would have been obvious based on descriptions such as "intimate contact" and production processes including hot press lamination of the cell elements.

Applicants respectfully traverse each of the Examiner's rejections under 35 U.S.C. §103(a) and the arguments and contentions set forth in support thereof, for at least the following reasons.

To begin with, Applicants respectfully reiterate that various embodiments of the claimed invention are directed to electrochemical cells for electrolysis of an aqueous solution of hydrogen chloride, which comprise: (a) an anode half-cell comprising an anode; (b) a cathode half-cell comprising a gas diffusion electrode as the cathode; and (c) an ion exchange membrane

comprising a perfluorosulfonic acid polymer which is positioned between (a) and (b); wherein the gas diffusion electrode has a surface having a geometric area, and wherein the ion exchange membrane has a surface having a geometric area, the surface of the ion exchange membrane comprises a layer of the perfluorosulfonic acid polymer with a support member embedded therein, *and wherein* the surface of the gas diffusion electrode and the surface of the ion exchange membrane are adjacent to each other and, *at a pressure of 250 g/cm² and a temperature of 60°C*, the gas diffusion electrode and the ion exchange membrane have a contact area of at least 50% of their geometric area.

The Examiner continues to contend that the pressure and temperature recited in the claims are *process* limitations. The Examiner is *incorrect* and this error must be addressed for a proper understanding of the invention. Moreover, the Examiner incorrectly states that Applicants have argued “that the temperature and pressure at which the gas diffusion electrode and membrane are laminated to be in intimate contact to achieve a contact area of greater than 50% is not taught.” (See, the Office Action, p. 16). Applicants do NOT argue that such conditions are for lamination to achieve the claimed contact area.

First, the recitation in the independent claim, “at a pressure of 250 g/cm² and a temperature of 60°C,” refers to *conditions at which the contact area* of a gas diffusion electrode and ion exchange membrane *are measured prior to construction of the claimed electrochemical cell* in order to ascertain whether or not the claimed contact area of at least 50% of the geometric areas of the surfaces is met. In other words, as described in Applicants’ Specification, for example, at page 2, lines 24-28 and Example 5, the contact area is *evaluated* for a given gas diffusion electrode and membrane prior to electrolysis cell construction, *under pressure and temperature conditions simulating cell operation*.

Second, Applicants’ Specification clearly shows that the mere application of such conditions (*i.e.*, a pressure of 250 g/cm² and a temperature of 60°C) does NOT necessarily result in the claimed contact area of at least 50% of the geometric area of the gas diffusion electrode and ion exchange membrane. As can be seen from Example 5, and the contact areas reported

therein, not every combination of electrode and membrane results in the claimed contact area. (See, Applicants' Specification, p. 15, Table 1). As explained in Applicants' Specification, electrodes and membranes with smooth surfaces are employed and the manner in which a support is embedded in the membrane and the manner in which a gas diffusion layer is applied are important to the smoothness. (See, e.g., Applicants' Spec., p. 3, line 4 through p. 4, line 6). Thus, as reflected in Table 1 of the Specification, the use of membranes with external supports (e.g., Nafion® 324) and/or gas diffusion electrodes with open-pore structures, do not provide the claimed contact area even at the recited conditions of a pressure of 250 g/cm² and a temperature of 60°C.

Thus, the Examiner's comment that the claimed pressure and temperature "process parameters" are not considered in a product-by-process claim is inapplicable in this instance. (See, the Office Action, p. 16). Claim 12, from which all other claims depend, is NOT a product-by-process claim. The recited pressure and temperature do NOT refer to conditions at which the cell is *constructed*. Rather, the recited pressure and temperature are conditions at which a claimed physical property of the structure is measured.

Applicants respectfully submit that none of the cited references, nor combinations thereof, teach or suggest each and every element of Applicants' claimed invention. Moreover, as explained further below, there is no rationale articulated on the record as to why one of ordinary skill in the art would be motivated to combine and modify the references in order to arrive at the claimed invention, much less with a reasonable expectation of successfully doing so. Thus, Applicants submit that none of the cited references or combinations thereof satisfy the criteria necessary to establish a *prima facie* case of obviousness.

None of the references teaches or suggest the claimed contact area. DeNora makes no explicit mention of the degree of contact. The mere reference to "intimate" contact in DeNora, or "close" contact in Shimamune, only indicates that the two elements touch each other. This does not imply any particular degree of contact area. As shown in Applicants' Specification, the pressure and temperature conditions of cell operation do not result in the

claimed contact area for all electrode/membrane combinations. Further, there is nothing in DeNora or Shimamune to suggest the claimed degree of contact area.

With respect to the teachings of Kolouch, Suzuki and Yoshida, Applicants respectfully point out that each of these references refers to the lamination of an ion exchange membrane and gas diffusion electrode (*i.e.*, hot pressing). The laminating of an electrolysis membrane and gas diffusion electrode provide a specific construction which is known in the art as a membrane electrode assembly ("MEA"). The MEA arrangement for electrochemical cells for electrolysis as described in Kolouch, Yoshida and Suzuki, *in contrast to the claimed invention*, raise several additional technical problems. For example, where a membrane and electrode are fused together (*e.g.*, laminated), the cathode cannot be separated from the electrolysis cell without also destroying the membrane or dismounting the same from the cell. In instances wherein the performance of only the electrode ceases to be adequate, the membrane would then also need to be exchanged when removing the electrode which increases repair/maintenance costs of the cell.

An additional disadvantage of the use of an MEA in an electrolysis cell is that MEAs cannot be used in electrolysis cells having large electrode areas (*e.g.*, typically an area greater than 2 m² in a single cell element). This is due at least in part to the fact that the material of the membrane, typically a perfluorosulfonic acid polymer and the electrode material have variable swelling behaviors when in contact with an electrolyte solution. The divergent degree of swelling can cause delamination of the electrode and membrane. Accordingly, such delamination can lead to low contact between the membrane and electrode resulting in higher electrolysis voltage. Alternatively, one of the materials with a different swelling degree can fracture wherein chlorine gas would be susceptible to entering other parts of the electrolysis cell, and/or the gas diffusion cell could be flooded by electrolyte resulting in the development of hydrogen gas. Clearly, either effect could be disastrous. Accordingly, Applicants respectfully submit that it is entirely unsuitable for an industrial scale electrolysis to follow the teachings of Suzuki, Kolouch and/or Yoshida in combination with any intent to maximize electrode surface

area. Moreover, again as shown in Applicants' Specification, the application of the recited temperature and pressure (*e.g.*, via lamination) does NOT necessarily result in the claimed contact area. Thus, the disclosure of laminated MEAs in these references does NOT teach or suggest the claimed invention.

Thus, Applicants respectfully submit that none of the cited combinations of references teaches or suggests each and every element of Applicants' claimed invention. More specifically, none of the references teach the claimed contact area of at least 50% of the geometric surface areas of the gas diffusion electrode and ion exchange membrane. As discussed above, mere reference to intimate contact or pressing fails to even suggest the claimed contact area. As shown in the examples in Applicants' Specification, without the proper selection of a gas diffusion electrode and ion exchange membrane, such contact areas are not achieved.

The Examiner contends that Suzuki discloses that reinforcing the membrane with a support web or mesh enables a lower (electrical) resistance of the membrane. However, this could only be applicable if a metallic support were used as a reinforcement because the PTFE material mentioned by the Examiner would not decrease the electrical resistance of the membrane (since PTFE is a **non**-electrically conducting material). However, increased conductivity from a metallic support is not necessarily desired. High electron conductivity of the membrane can be detrimental and undesirable. Particularly, in the case of close contact between cathode, anode and membrane, a short circuit may result where the membrane has too high an electron conductivity.

The performance of a membrane is more closely related to *proton conductivity*. Proton conductivity is distinguished from mere electrical current conductivity and is the more important measure for the performance of the membranes. (*See, e.g.*, the Rodgers reference, J. MEMBRANE SCI. 321:100, submitted in the accompanying IDS, Abstract and Section 3.2.2; and the Jung reference, J. FUEL CELL SCI. & TECH., 4:248, Abstract "... cell performance ... is lower ... *due to poor proton conductivity* ...").

Contrary to the Examiner's proposed combinations of references, it is generally known in the art that a reinforcement of the membrane *decreases* the proton conductivity of the membrane. For example, U.S. Pat. No. 4,954,388 (cited in the accompanying IDS) specifically states that, "... resistance in aqueous media of this reinforced ... structure is considerably higher than that of an unreinforced thinner membrane ... " (*See*, col. 1, lines 47-52). The Rodgers reference clearly states that, "[u]sing reinforcing materials results in a reduction in important membrane properties ... , such as proton conductivity ... " (*See*, Rodgers, Abstract). Jung makes it clear that the thicker membrane resulting from the use of PTFE mesh as a support decreases proton conductivity. (*See*, Jung, Abstract). The Sudoh reference (also cited in the accompanying IDS), makes it clear that, "the proton conductivity of the membrane reinforced with the PTFE sheet decreased ... " (*See*, Sudoh, Abstract). Finally, the English abstract of the Takenaka reference (also cited in the accompanying IDS) states, "... membranes reinforced by Teflon textile had greater mech[anical] strength and smaller dimensional change than the unreinforced membranes, but their usages for the SPE-water-electrolysis resulted in an increased ohmic drop due to the higher membrane resistance ... " (*See*, Takenaka, Abstract).

Thus, the Examiner's assertion that one of ordinary skill in the art would be motivated to combine the allegedly suggested high contact area of DeNora, Kolouch or Shimamune with the membrane support teachings of Suzuki to improve conductivity performance of the membrane is technically incorrect.

In fact, given that each of Kolouch, Yoshida and Suzuki are directed to laminated MEAs which are different from the claimed invention, and since the use of a support materials was known to decrease proton conductivity in membranes, one of ordinary skill in the art would have no reasonable expectation of successfully improving membrane performance by the combinations and modifications suggested by the Examiner.

Accordingly, Applicants submit that none of the cited combinations of references satisfy the criteria necessary to establish a *prima facie* case of obviousness with respect to the

claimed invention. Accordingly, reconsideration and withdrawal of the obviousness rejections set forth in the Office Action are respectfully requested.

In conclusion, Applicant submits that all pending claims patentably distinguish over the prior art of record. Reconsideration, withdrawal of all rejections and a Notice of Allowance are respectfully requested.

Respectfully submitted,

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